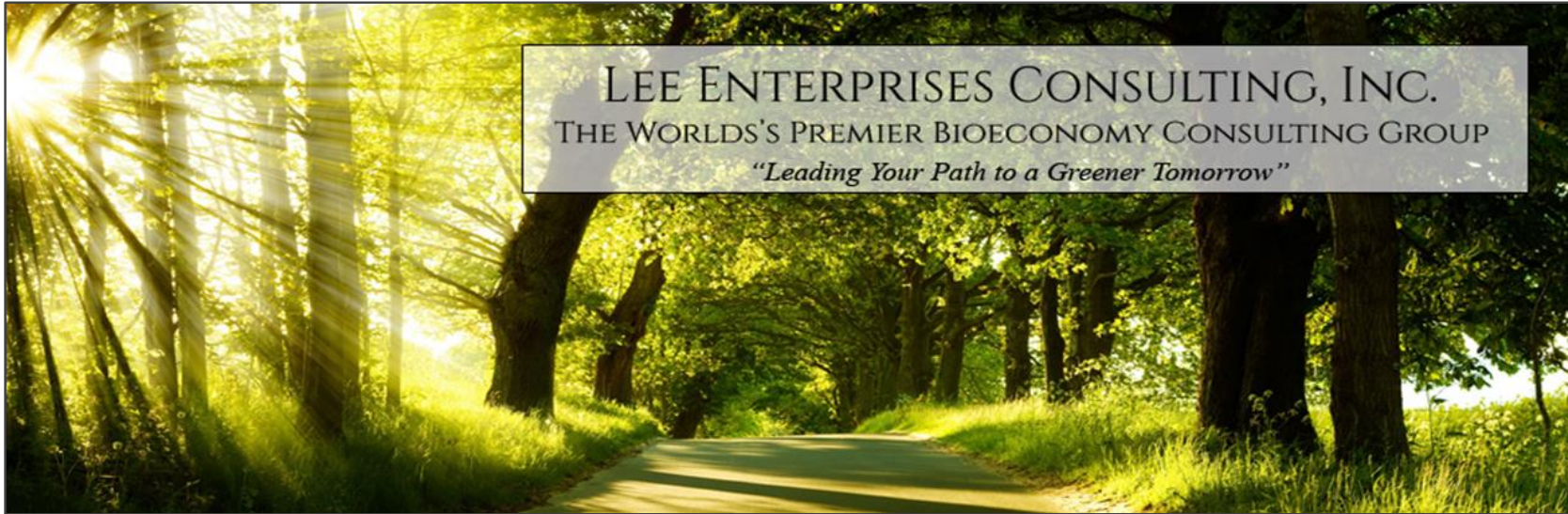


# Techno-economic modeling & analysis in the bioeconomy



Techno-economics for technology investors.

[ Part 2 of 4 ]



LEE ENTERPRISES CONSULTING, INC.  
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# Renewables technology investing presents unique challenges.



Investing in a new process technology is different than, for example, investing in a new mobile app. It's not like you can lock a bunch of twenty-three year old engineers in a closet for the weekend and expect them to emerge with a minimum viable product.

Capital and operating costs are high and depend strongly on the results of R&D and scale-up. Further, lengthy timelines increase chances that market conditions will change.

The impact of these factors can be difficult and time-consuming to estimate. So, they are often visited once at the beginning of a project and then largely ignored in favor of the tasks at hand.

This doesn't have to be the case. *Techno-economic modeling offers a way to rapidly assess and reassess profitability and risk in terms of process and market parameters* - a tool to select winning investments and to maximize their chances of success.

# Aiming for success quantitatively



## Evaluation stage

To identify winning technologies, you need to *accurately estimate economic value* for baseline and projected cases, using metrics like NPV and IRR.

You also need to assess potential *technology and market risks*. Technology risk is unavoidable when doing something for the first time. Market risks include fluctuations in raw material and product prices.













## Execution stage

After you have made an investment, your focus shifts to facilitating development and tracking progress. Your goal is to maximize chances of success and minimize time to market.

By *identifying and focusing on critical process parameters*, you maximize R&D efficiency. Through *regular reevaluation*, you quantitatively track progress and adapt quickly to changing priorities.

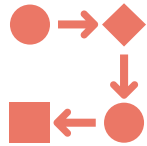
# Tools of techno-economic analysis

Techno-economic modeling links economic value to process and market parameters. By combining it with sensitivity analysis like Tornado and Monte Carlo analysis, you can identify the parameters that are most critical to success and the risks that threaten it.

	Techno-Economic Modeling	Tornado Analysis	Monte Carlo Analysis
<b>Evaluation stage</b>			
Economic value assessment			
Technology risk assessment			
Market risk assessment			
<b>Execution stage</b>			
Identify key opportunities			
Track progress			
Adapt to changing priorities			
Test risk mitigation strategies			

# An objective basis for communication.

A good *techno-economic model captures your best current understanding of a technology*, from lab findings to labor requirements. In this capacity it can enable more clear and objective communication, like a yardstick for progress.



Agree on priorities



Track and demonstrate progress



Set stage-gates



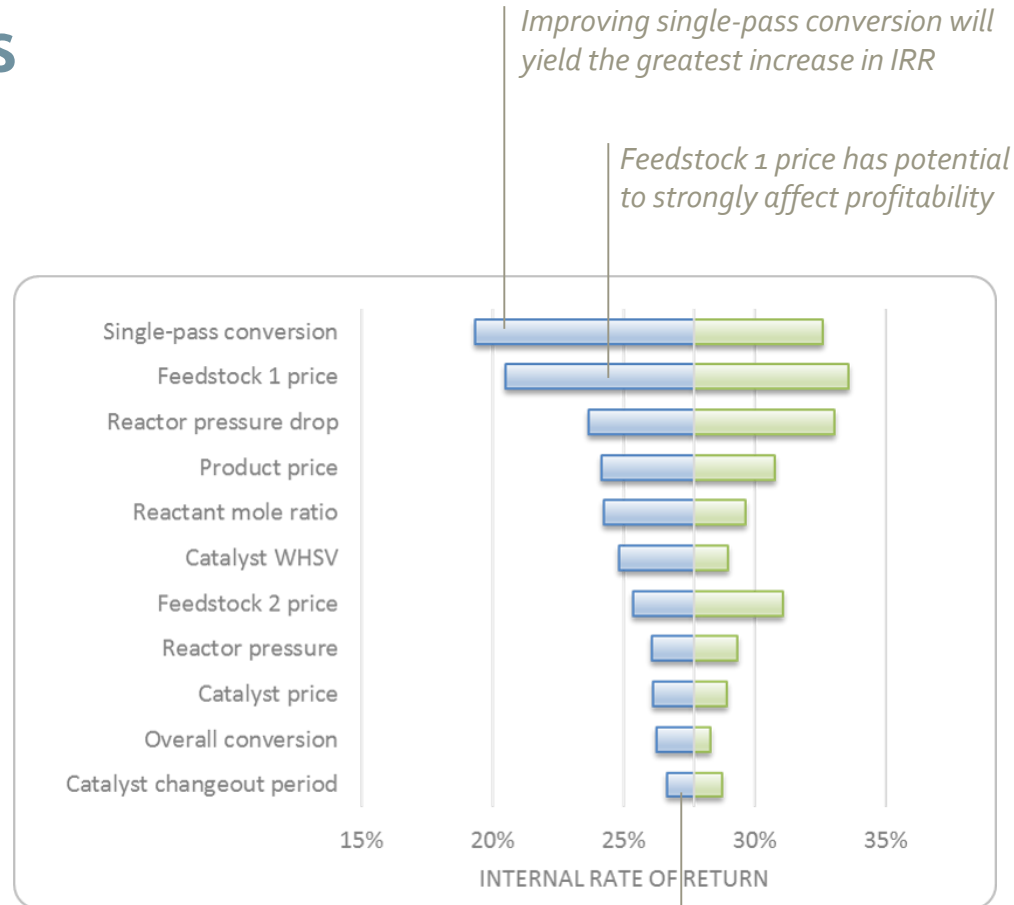
Change directions early to avoid dead-ends

# Identifying key variables with Tornado Diagrams

*Tornado diagrams help direct R&D efforts to the highest impact parameters.*

Tornado diagrams compare the impact of process and economic parameters on economic value. They identify the key variables that are critical to profitability.

Tornado diagrams are typically time-consuming to build, so they are underutilized despite being an excellent tool for prioritizing development. This is why *LEC engineers have developed proprietary software that lets you build them at the touch of a button.*



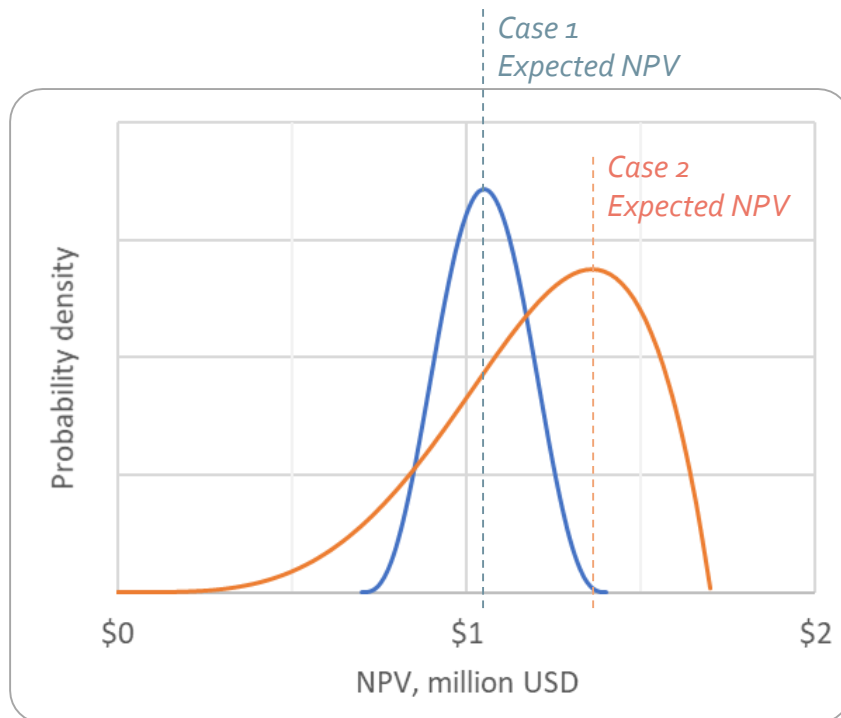
*Further effort to improve catalyst changeout period will have minimal impact on IRR*



# Quantifying risk with Monte Carlo Analysis

By compiling the results of thousands of simulation cases, Monte Carlo analysis brackets the range of possible outcomes and predicts the probability that any given case will occur.

Monte Carlo analysis is especially useful for quantifying the risk associated with fluctuations in raw material and product prices and for understanding the implications of uncertainty in CapEx, OpEx, and revenue.



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*Monte Carlo analysis lets you quantify the risk associated with market fluctuations and other kinds of uncertainty.*

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Coming up next in  
the series.



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*This is the second in a four-part series on techno-economic analysis for new technologies in the bioeconomy. The next installment will look at leveraging techno-economics from the technology developer's perspective.*

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## Techno-economic modeling & analysis in the bioeconomy

1. What is techno-economic modeling and analysis?
2. Techno-economics for technology investors.
3. Techno-economics for technology developers.
4. Advantages of using a third party.

## Chris Burk, PE Professional bio



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Chris specializes in techno-economic analysis. He works with companies that are developing or investing in new chemical and bioprocess technologies, helping them use techno-economic modeling to better understand their economics at a commercial scale. His clients include venture capital firms, universities, national labs, independent startups, and startup incubators.

Prior to consulting, Chris spent twelve years in industry working in R&D, scale-up, and pilot plant EPC. He speaks and writes regularly on the importance and best practices of early-stage cost modeling.

He is a licensed Professional Engineer and he holds BS and MEng degrees in Chemical Engineering from Cornell University.



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